Comparative Analysis of Boost and Cascaded Boost Converter

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Abstract: - In this paper, an overall comparison between the Boost Converter (BC) & Cascaded Converter or Cascaded Boost Converter (CBC) is given in terms of ideal condition, as well as with the consideration of Equivalent Series Resistance (ESR) of inductor. The loss comparison in the two converters due to the ESR is also included in this paper. It is seen that in CBC, voltage gain is more but the power loss due to ESR is also more compared to the BC. The parameters of the converters are found out with a consideration of per unit ripple quantity of inductor current and capacitor voltage. A boundary condition between the continuous conduction mode (CCM) & discontinuous conduction mode (DCM) of the inductor current is also shown. The behaviour of the capacitor current for the converters is discussed during ON and OFF condition of the switch(es). At the end, the simulation results of both the converters are given for a 20V/100V, 100 W output. The analysis and simulation results are presented in this paper for the verification of the feasibility.

Key-Words: - boundary condition**,** capacitor current, cascaded converter, DC-DC converter, inductive ESR, ESR loss comparison, simulation

1 Introduction

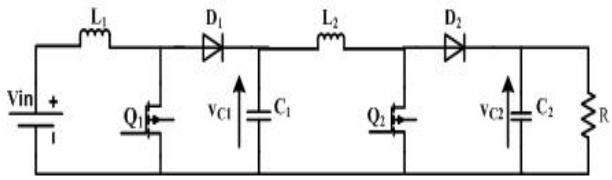
DC - DC conversion is becoming very important in various portable applications now a days. Many portable devices use power at different levels of voltage. The modern technology is making the renewable energy sources (RES) to become an alternative of the combustion engines for power generation as the cost and the environmental issues are concerned.[1-6]But the main hindrance behind RES is less voltage generation per cell.[7] So to fulfill the requirement of high voltage applications, a number of cells to be connected is series or parallel combination. It further reduces the energy generation due to shadow effect on the PV cells.[8-11] So a voltage step up process can be used with a fuel cell (FC) or Photovoltaic (PV) cell to boost the output voltage and thus the efficiency can also be increased.[12-13] As the dc-dc converter injects less current ripple into the source, the efficiency as well as the life span can be increased with that for the PV or FC array. [14-15]

The voltage build up can be possible by BC and CBC. [16-17]BC can not give the significant build up of output voltage for the same duty ratio as compared to CBC as the output voltage of the later one is a quadratic function of duty cycle. Again for BC as high voltage generation requires a large duty cycle, so it further inceases the reverse recovery effect of the diodes.[18-19]

The comparative study of the two converters is focussed in this paper along with the consideration of ESR of the inductor(s) in section 3 and power losses due to the ESR effect is discussed in section 4. In section 5, converter parameters are designed with a discussion about the stresses on the switch(es). Section 6 depicts about the boundary condition between continuous conduction mode (CCM) & discontinuous conduction mode (DCM) of inductor current. Behaviour of the capacitor current and the simulation performances are shown in section 7 & 8 respectively.

2 Operation of the Converters

2.1 Cascaded Boost Converter:



(a)

on the switch Q_1 as well as diode D_1 is 9.85 A. Current stress on Q_2 & D_2 is 4.43 A. It is clear that the ripple present in the voltage and current is 2% each. The voltage & current is a bit less due to the parasitic losses in the circuit.

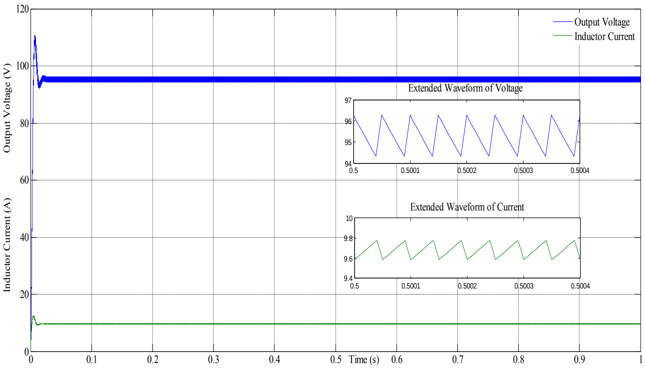


Fig.10 Output voltage & Inductor Current waveforms are shown for BC

Fig. 10 shows the output voltage waveform as a constant at 96 V, inductor current at 10 A. the inductor current is continuous in nature. The peak value of i_L is 9.9 A. So the current stress on the switch Q as well as diode D is 9.9 A. It is clear that the ripple present in the voltage and current is 2% each. Here also some losses present due to parasitic effect.

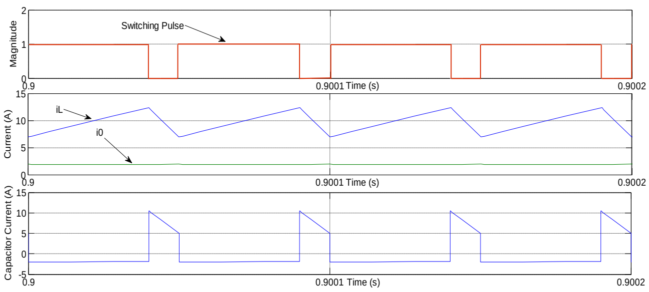


Fig.11 shows the switching pulse, inductor current with output current waveforms & capacitor current waveform for BC when $I_{Lmin} > I_0$

As discussed in section 7, the simulation result of the behaviour of the capacitor current for the BC is shown in fig. 11. Here $I_{Lmin} > I_0$, so the capacitor discharges through the load during ON time of the switch Q, whereas during OFF time of the switch, the capacitor gets charged.

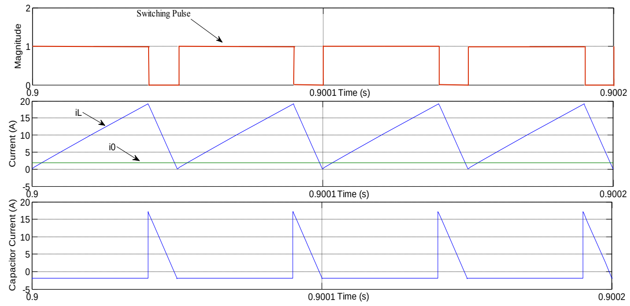


Fig.12 shows the switching pulses, inductor current with output current waveforms & capacitor current waveform for BC when $I_{Lmin} < I_0$

Fig. 12 shows the simulated result of the behaviour of capacitor current when I_{Lmin} falls below I_0. The capacitor discharges during the ON state of the switch as usual. But during OFF state of the switch, capacitor gets charged only when I_{Lmin} more than I_0. At once the capacitor starts to discharge through the load even though the switch in OFF state when I_{Lmin} becomes less than the load current.

The capacitor currents for the CBC also show the same behavior as the BC capacitor current shown above.

9. Conclusion

The main idea behind this paper is to get a clear view of the comparative study of the two converters. The CBC can give a high voltage gain compared with the BC for a given duty ratio. As the switching frequency is fixed, for the same load if the duty ratio is less, the voltage and current ripple is also be less. So the CBC is better option compared to BC. But when ESR losses are considered, the BC is good. That's why for high power application where ESR losses are not a constraint, CBC can be used; whereas for low power application BC is a right choice.

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